

## CLAIMS

1 A safety relief valve comprising:

a) a body comprising a chamber therein and an inlet and an outlet, the inlet comprising an inlet valve seat;

5 b) a disk member closable on the inlet valve seat; and

c) a mechanism in the body biasing the disk member to rest on the inlet valve seat with a set force such that when the pressure in the inlet exceeds a set pressure resulting from the set force, the disk member is lifted from the inlet valve seat, the mechanism comprising a combination of a coil spring and one or more disk springs stacked in series with the coil spring.

2. The safety relief valve of claim 1 further comprising a secondary orifice between the chamber and the outlet, the secondary orifice being sized so that gas flows from the inlet valve seat into the chamber in a sonic flow and so that gas flows from the chamber through the secondary orifice in a sonic flow when the valve opens due to a pressure in the inlet exceeding the set pressure.

3. The safety relief valve of claim 1 wherein the mechanism further comprises an adjustment screw acting against the combination of coil spring and one or more disk springs.

20 4. The safety relief valve of claim 3 wherein the adjustment screw has a bore therein that receives a stem on the disk member when the disk member is lifted from the inlet valve seat.

5. The safety relief valve of claim 1 having a blow-down value of less than about 10%.

25 6. The safety relief valve of claim 1 having a blow-down value of less than about 5%.

7. The safety relief valve of claim 1 comprising a plurality of disk springs.

8. The safety relief valve of claim 7 wherein at least two of the disk springs are stacked to operate in series.

5 9. The safety relief valve of claim 7 wherein at least two of the disk springs are stacked to operate in parallel.

10. The safety relief valve of claim 7 wherein there are at least three disk springs, and at least two of those are stacked facing in an opposite direction to the third disk spring.

10 11. The safety relief valve of claim 2 wherein the secondary orifice is formed in a plate that is inserted into the body of the safety relief valve.

12. The safety relief valve of claim 2 wherein the secondary orifice is formed integral with the body of the safety relief valve.

15 13. A method of manufacturing a group of safety relief valves each with a blow-down value of less than about 10%, the group covering a range of set pressures, the method comprising:

a) manufacturing multiple bodies, each having a chamber within the body, an inlet and an outlet, the inlet comprising an inlet valve seat;

20 b) fitting a disk member within each of the bodies so as to be closeable on the inlet valve seat within the body;

c) obtaining a plurality of coil springs to be used in the group of safety relief valves, each spring having an original spring rate, the original spring rates varying within the plurality of springs;

d) measuring the original rate of each spring;

25 e) assembling the valve by placing a given spring within a given body so as to act with an adjustable force on the disk member, the given spring having its original spring rate modified prior to the final assembly of the valve.

14. The method of claim 13 wherein the spring rate is modified by having one or more disk springs stacked in series with the coil spring.

15. The method of claim 13 wherein the spring rate is modified by shorting out a portion of the coils of the spring.

5 16. The method of claim 13 wherein the spring rate is modified by having a portion of the surface of the spring removed.

17. The method of claim 16 wherein the spring has material removed from its inside diameter.

10 18. The method of claim 16 wherein the spring has material removed from its outside diameter.

19. The method of claim 13 wherein the spring rate is modified by mechanically enlarging the internal diameter of the spring.

15 20. A snap-type safety relief valve designed for use under specified operating conditions on a pressure vessel or a flow line having a pressurized gas therein, the safety relief valve comprising:

a) a body attachable to the pressure vessel or flow line, the body comprising a chamber therein and an inlet and an outlet, the inlet comprising an inlet valve seat, the outlet being adapted to attach to outlet piping;

20 b) a disk member closable on the inlet valve seat;

c) a mechanism in the body comprising a spring having a modified spring rate biasing the disk member to rest on the inlet valve seat with a set force such that when the pressure in the pressure vessel exceeds a set pressure resulting from the set force, the disk member is lifted from the inlet valve seat; and

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d) a secondary orifice between the chamber and the outlet, the secondary orifice being sized so that gas flows from the inlet valve seat into the chamber in a sonic flow and so that gas flows from the chamber

through the secondary orifice in a sonic flow when the valve opens due to a pressure in the pressure vessel or flow line exceeding the set pressure during testing under the specified operating conditions.

5           21.     The relief valve of claim 20 wherein the spring rate has been modified by having one or more disk springs stacked in series with the coil spring.

          22.     The relief valve of claim 20 wherein the spring rate has been modified by shorting out a portion of the coils of the spring.

10           23.     The relief valve of claim 20 wherein the spring rate has been modified by having a portion of the surface of the spring removed.

          24.     The relief valve of claim 20 wherein the spring rate has been modified by mechanically enlarging the internal diameter of the spring.

15           25.     The relief valve of claim 21 wherein the one or more disc springs have a hole in their center, and the mechanism comprises an adjustment screw extending through the holes in the one or more disk springs.

          26.     A combination of outlet piping and a snap-type safety relief valve designed for use under specified operating conditions on a pressure vessel or flow line having a pressurized gas therein, the combination comprising:

20               (a)     a safety relief valve body attachable to the pressure vessel or flow line, the body comprising a valve body chamber therein and an inlet and an outlet, the inlet comprising an inlet chamber upstream of an inlet valve seat, the outlet being attached to the outlet piping, a portion of the outlet piping creating an outlet chamber proximal to the outlet;

                 (b)     a disk member closable on the inlet valve seat;

25               (c)     an adjustment screw acting on a spring having a modified spring rate in the body biasing the disk member to rest on the inlet valve seat with a set force such that when the pressure in the pressure vessel exceeds

the set pressure resulting from the set force, the disk member is lifted from the inlet valve seat; and

(d) a secondary orifice between the valve body chamber and the outlet, the secondary orifice being sized so that pressure in the valve body chamber is less than about 50% of the pressure in the inlet chamber and so that pressure in the outlet chamber is less than about 50% of the pressure in the valve body chamber, when the valve opens due to a pressure in the pressure vessel or flow line exceeding the set pressure during testing under the specified operating conditions.

27. An improved low blow-down snap-type safety relief valve having an inlet, a disk member closable on the inlet, a mechanism biasing the disk member on the inlet, a body, and an outlet, the improvement comprising the valve preventing built-up downstream back pressures from changing its blow down value by including a secondary orifice in the body of the safety relief valve sized to permit gas to escape from the body through the secondary orifice in a sonic flow when the valve is opened during testing under operating conditions specified for the use of the valve, and the mechanism comprises a spring having a modified spring rate.

28. A method of preparing a coil spring for use in a pressure relief valve comprising:

- a) measuring the spring rate of the coil spring and;
- b) modifying the spring so as to modify its spring rate to be within  $\pm 2\%$  of a desired spring rate.

29. The method of claim 28 wherein the spring rate is modified by having one or more disk springs stacked in series with the coil spring.

30. The method of claim 28 wherein the spring rate is modified by shorting out a portion of the coils of the spring.

31. The method of claim 28 wherein the spring rate is modified by having a portion of the surface of the spring removed.

32. The method of claim 31 wherein the spring has material removed from its inside diameter.

33. The method of claim 31 wherein the spring has material removed from its outside diameter.

5           34. The method of claim 28 wherein the spring rate is modified by mechanically enlarging the internal diameter of the spring.

10           35. An improved low blow-down safety relief valve having an inlet, a disk member closable on the inlet, a mechanism biasing the disk member on the inlet, a body, and an outlet, the improvement comprising the mechanism comprising a spring having a modified spring rate.